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**TARDIGRADA FROM THE GALÁPAGOS AND
COCOS ISLANDS**

By

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and

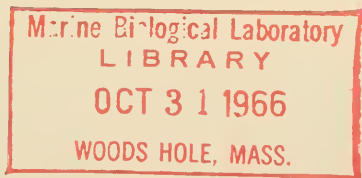
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Participation in the Galápagos International Scientific Project gave the senior author an opportunity to collect a series of tardigrades along with other material on several islands of the Galápagos Archipelago, Ecuador, and on Cocos Island, Costa Rica. This Project covered the period from January through early March, 1964. It was sponsored by the Charles Darwin Foundation, the University of California (Berkeley), and the California Academy of Sciences, with principal financial support from the National Science Foundation (Grant GE 2370), the Belvedere Scientific Fund of San Francisco, and the Shell Oil Company. Tactical support was furnished by the navy of the Republic of Ecuador, and the United States Navy. Logistics were handled by the University of California Extension Division.

Samples of representative habitats were collected by the senior author mainly from the south side of Santa Cruz Island, the vicinity of Guayaquil, Ecuador, and from Chatham Bay, Cocos Island. Additional samples were taken by other members of the expedition, as indicated in the collection data. One sub-sample of most collections was washed at the Darwin Research Station at Academy Bay, Santa Cruz Island, fixed in hot water, and preserved in 5 percent formalin. The remainder of each sample was dried for later processing. Representative tardigrades from each sample were mounted singly in Hoyer's or in Fauré's formulas for microscopic study.

Samples were taken during the spring, and occasional precipitation wet most of the collecting areas. However, those stations below 35 meters were exceedingly dry between rains. Cryptograms on soil, rocks, and vegetation were



the most productive habitats. Baermann funnel extractions of organisms from a comparable number of soil samples yielded no tardigrades.

The study area on Santa Cruz Island included the seashore from Punta Nuñez to Pelican Bay, the old trail to Bella Vista, and the trail from Horne-man's Farm to the grassland area. Altitudes are approximations based on known points determined by Dr. Robert L. Pyle, meteorologist of the United States Weather Bureau, from barograph readings. The collections are listed according to specific islands in the Galápagos Archipelago, and for Santa Cruz Island, by altitude from sea level to about 500 meters. The islands are identified by their proper Ecuadorian names with common English equivalents in parentheses. Distribution information is given later for each species by number, referring back to this section for details.

The results of this study show mainly that most of the species of tardigrades so far collected in the Galápagos Islands are already known on the continents. Two species presumed to be endemic ultimately may be discovered in the faunas of Central or South America. This study also points out the similarity of the Galápagos tardigrade fauna to those of Brazil and the United States. This is due undoubtedly to the existence of knowledge about tardigrades in the Brazilian and the United States faunas and the lack of it in the faunas of Central and South America, excluding Brazil.

We appreciate the kindness of Dr. William A. Weber, of the University of Colorado, who identified the plant material, and of Dr. G. Ramazzotti, who confirmed the identifications of the tardigrades in the genera *Echiniscus* and *Macrobiotus*. The plant specimens have been deposited in the Department of Botany, University of California at Davis, and the tardigrada in the Department of Entomology of the same institution.

COLLECTION DATA

DARWIN ISLAND (Culpepper).

67. *Ramalina* sp., on *Croton*, II-1-1964, D. Q. Cavagnaro.

WOLF ISLAND (Wenman).

68. Lichen species not determined, on cliffs near top of island, I-31-1964, D. Q. Cavagnaro.
70. Lichen species not determined, on *Croton* and *Scalesia*, from upper plateau, I-31-1964, D. Q. Cavagnaro.
71. Lichen species not determined, on *Croton*, near summit, I-31-1964, D. Q. Cavagnaro.

FERNANDINA ISLAND (Narborough).

- 105 and 106. Feces of a probably extinct species of tortoise, in "meadow" of wet pumice, II-6-1964, J. R. Hendrickson.
95. *Anaptychia tropica kurokawa* var. *antillarum* (Vainio), from *Bursera* forest zone, 335 meters, II-6-1964, D. Q. Cavagnaro.

PINZÓN ISLAND (Duncan).

96 and 151. *Ramalina usnea* (Linnaeus), *Teloschistes flavicans* (Swartz), *Parmelia* sp., and *Micromitrium* sp., on lava and *Croton*, 340 meters, II-7-1964, D. Q. Cavagnaro.

97 and 146. *Frullania* sp., *Anaptychia leucomelaena*, *Pseudocyphellaria aurata* (Acharius), *Teloschistes flavicans* (Swartz), *Parmelia* sp., and *Usnea* sp., at summit area, II-7-1964, D. Q. Cavagnaro.

SANTA CRUZ ISLAND (Indefatigable).

Marine

60. Punta Nuñez, in washings of barnacles from high and midtide zone, II-1-1964, R. O. Schuster.

167. Darwin Research Station, in washings of coral from tide pools in reef near station dock, II-14-1964, R. O. Schuster.

Darwin Research Station below the barranco (50-foot lava cliff back of station).

166. *Parmelia tinctorum* Desportes, on dead tree, I-29-1964, R. O. Schuster.

153. *Ramalina* sp., less than 10 meters, I-21-1964, R. O. Schuster.

161. *Ramalina usnea* (Linnaeus), and *Parmelia tinctorum* Desportes, on dead *Mayetina*, less than 10 meters, I-20-1964, R. O. Schuster.

162. *Parmelia* sp., on *Acacia*, I-29-1964, R. O. Schuster.

38. *Ramalina* sp., 15 meters, I-28-1964, R. O. Schuster.

158. *Parmelia tinctorum* Desportes, on *Bursera*, I-25-1964, R. O. Schuster.

147. *Ramalina* sp., 25 meters, I-21-1964, R. O. Schuster.

47. Lichen species not determined, 25 meters, I-28-1964, R. O. Schuster.

Above the barranco, near seismic station, approximately 40 meters.

159. *Teloschistes flavicans* (Swartz), *Parmelia* sp., and *Ramalina* sp., I-29-1964, R. O. Schuster.

160. *Ramalina* sp., I-29-1964, R. O. Schuster.

163. *Parmelia tinctorum* Desportes, *Ramalina* sp., and *Rocella babingtonii* Montagne, I-29-1964, R. O. Schuster.

Old trail to Bella Vista.

80. *Parmelia* sp., *Cladonia* sp., and *Campylopus* sp., very dry, 35 meters, II-4-1964, R. O. Schuster.

107. Moss and lichen, species not determined, 35 meters, II-2-1964, R. O. Schuster.

86. *Parmelia tinctorum* Desportes, 70 meters, II-4-1964, R. O. Schuster.

149. *Ramalina* sp., 70 meters, II-4-1964, R. O. Schuster.

81. *Parmelia tinctorum* Desportes, and *Ramalina usnea* (Linnaeus), on bark, 90 meters, II-4-1964, R. O. Schuster.

82. (? *Hymenostomum*), on soil, 90 meters, II-4-1964, R. O. Schuster.

83. *Frullania* sp., on rock, 90 meters, II-4-1964, R. O. Schuster.

85. *Micromitrium* sp., 90 meters, II-4-1964, R. O. Schuster.

156. *Parmelia tinctorum* Desportes, on log, 90 meters, II-4-1964, R. O. Schuster.
165. *Frullania* sp., *Parmelia* sp., and *Ramalina* sp., 90 meters, II-4-1964, R. O. Schuster.
107. Moss and lichen, species not determined, 35 meters, II-12-1964, R. O. Schuster.

Horneman Farm to grassland.

150. Moss and *Parmelia latissima* Fee, Horneman Farm, 237 meters, II-15-1964, R. O. Schuster.
126. Moss species not determined, II-16-1964, R. O. Schuster.
- 127 and 130. *Meteoriopsis* sp., and *Parmelia latissima* Fee, on coffee tree, Horneman Farm, 237 meters, II-15-1964, R. O. Schuster.
135. Moss species not determined, on rocks near bamboo groves, 260 meters, II-15-1964, R. O. Schuster, D. Q. Cavagnaro.
116. *Riccia* sp., on rocks in canyon, *Miconia* zone, 400 meters, II-17-1964, R. O. Schuster, D. Q. Cavagnaro.
154. Hepatic species not determined, and fungus, *Miconia* zone, 450 meters, II-17-1964, R. O. Schuster.
141. Moss, *Frullania* sp., and *Sticta* sp., *Miconia* zone, 450 meters, II-17-1964, R. O. Schuster.
123. *Octoblepharum albidum* Hedwig, *Miconia* zone, 450 meters, II-17-1964, R. O. Schuster, D. Q. Cavagnaro.
134. Hepatic and *Sticta* sp. on *Miconia*, 450 meters, II-17-1964, R. O. Schuster, D. Q. Cavagnaro.
125. *Lycopodium complanatum* Linnaeus, 490 meters, II-17-1964, R. O. Schuster, D. Q. Cavagnaro.

JENSEN ISLAND (off shore from Academy Bay, Santa Cruz Island).

92. *Ramalina* sp., on dead bushes, II-8-1964, R. O. Schuster.

SANTA MARÍA ISLAND or Floreana (Charles Island).

90. Moss species not determined, 245 meters, II-6-1964, C. B. Koford.
91. Mixed lichen species not determined, II-6-1964, C. B. Koford.

ECUADOR, GUAYAQUIL.

Moss and *Physcia* sp., on trees, III-4-1964, R. O. Schuster.

COSTA RICA, COCOS ISLAND.

Chatham Bay, III-8-1964, R. O. Schuster.

1. *Plagiochila* sp., *pilotrichum bipinnatum* (Schwaegrichen) Mitten, and *Meteoriopsis qatula* (Hedwig) Brotherus.
2. *Octoblepharum albidum* Hedwig.
3. Hepatics, and *pilotrichum bipinnatum* (Schwaegrichen) Mitten.

SYSTEMATICS

Suborder	HETEROTARDIGRADA Marcus, 1927
Superfamily	ECHINISCOIDEA Marcus, 1927
Family	OREELLIDAE Ramazzotti, 1962
Genus	Echiniscoides Plate, 1889

Echiniscoides sigismundi (Schultze, 1865).

(Figure 1.)

Specimens measure up to 300μ in length but are usually smaller. The species is colorless or nearly transparent with a slight greenish or brownish cast. Large black eyes are present. The most obvious and distinguishing character is the number (6, 8, or more) of claws on each leg.

This is an exclusively marine tardigrade often collected from algae in the collars of barnacles. It is a cosmopolitan species. Specimens were recovered from both Santa Cruz Island marine localities 60 and 167.

Archechiniscus Schulz, 1953**Archechiniscus marci** Schulz, 1953.

(Figure 2.)

The length is about 200μ . The body is nearly transparent with smooth cuticle and obscure segmentation. Nine body segments have been noted by Schulz. Large eye spots are present. The external claws are implanted on the legs and have basal spurs, while the internal claws are separated from the legs by toe-like appendages and are without spurs.

This marine tardigrade was known previously from the coast of El Salvador. One example was recovered from Santa Cruz Island, sample number 167.

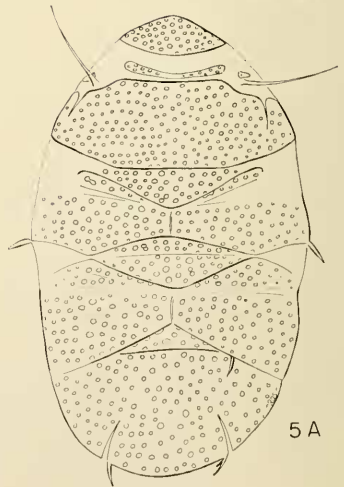
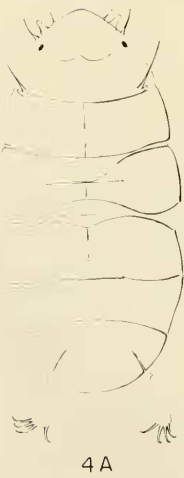
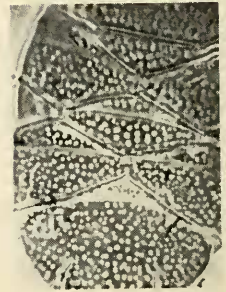
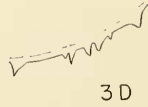
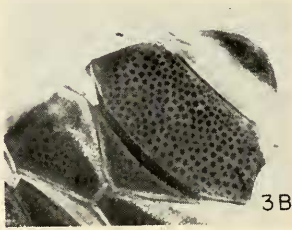
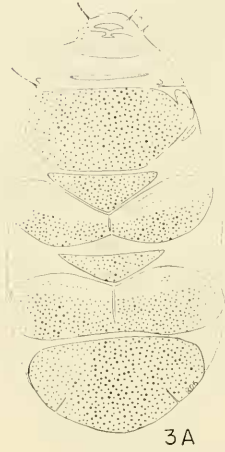
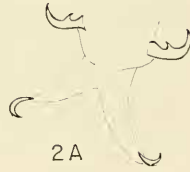
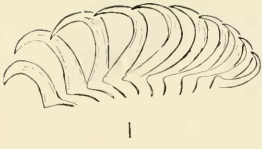
Family	ECHINISCIDAE Thulin, 1928
Genus	Echiniscus Schultze, 1840

Echiniscus viridis Murray, 1910.

(Figure 3.)

The length is about 250μ , and the body is dark green. The cuticular markings consist mainly of darker-green thickened areas on a lighter-green cuticle. Transverse bands of smaller polygons on colorless cuticle are present at the anterior margin of plates B and C. Spine A is about 25μ long on specimens of 250μ and it is the only lateral spine present. Dorsal spines are absent. Each leg has a plate, and leg IV has a collar of distinctly spaced teeth. The internal claws of legs IV have a basal spur.

This species is recorded from Brazil, Hawaii, and Scotland. Five specimens were collected on Santa Cruz Island, on the old trail to Bella Vista, sample numbers 80, 86, and 107.



***Echiniscus cavagnaroi* Schuster and Grigarick, new species.**

(Figure 5.)

Length 210 μ . Eye spots absent. Dorsal plates C and D longitudinally divided, and anterior halves transversely divided by 2 smooth bands. Intersegmental plates II and III transversely divided. Plates present on all legs. Dentate collar on leg IV with 8 to 12 acuminate teeth. Venter simple. Internal buccal spine shorter than external, spines about 15 μ long; buccal papilla 7 μ long, spine A 50 μ , and clava 5 μ . Lateral spine C and spine E 8 μ long (spine E is sometimes dichotomous and spine D^d is occasionally present, as on the specimen illustrated). Dorsal plates punctate, with larger pores of about 3 μ diameter in random pattern, and with smaller pores of $\frac{1}{2}\mu$ to 1 μ diameter. Inner claws of each leg with small basally directed spur.

Holotype from Santa Cruz Island, old Bella Vista trail, sample number 165, deposited in the Department of Entomology, University of California, Davis. Eighteen paratypes were found in samples 81, 83, 86, and 165. Paratypes deposited at Davis and at the California Academy of Sciences, Department of Invertebrate Zoology. The lengths of 19 specimens were rather evenly distributed between 160 μ and 220 μ . This species keys to *E. calcaratus* in Ramazzotti (1962), but differs by having claws with a basal spur, and by having a third median plate.

We take pleasure in naming this species for David Q. Cavagnaro who collected tardigrades from many islands of the Galápagos Archipelago.

***Echiniscus kofordi* Schuster and Grigarick, new species.**

(Figure 6.)

Length 190 μ . Eye spots absent. Dorsal plates C and D longitudinally divided, and with obscure transverse divisions. Median plates I, II, and III present with transverse division of II obscure (distinct on some specimens of the series). Scapular and terminal plates have raised, intersecting bands, plates C and D with one longitudinal band laterad. Incision of terminal plate very weak, represented by a thin line. Internal buccal spine 10 μ long, papilla 7 μ , external spine 12 μ . Seta A 22 μ long, clava 5 μ . Spine A the only lateral or dorsal spine present. Dorsal plates covered with large irregularly placed granules of

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FIGURE 1. *Echiniscoides sigismundi* (Schultze). Claws.

FIGURE 2. *Archechiniscus marci* Schulz. 2B body, 2A legs IV.

FIGURE 3. *Echiniscus viridis* Murray. 3A body, 3B photomicrograph of cuticle, 3C inner claw leg IV, 3D collar leg IV.

FIGURE 4. *Pseudechiniscus juanitae* Barros. 4A body, 4B pseudosegmental plate, 4C cuticle granulation, 4D inner claw leg IV.

FIGURE 5. *Echiniscus cavagnaroi*, new species. 5A, dorsum; 5B, photomicrograph of cuticle.

up to 2.5μ diameter. Plates faint on legs I–III, developed on leg IV. Leg IV with collar of about 12 acuminate teeth. Internal claws of leg IV with small basally directed spur.

Holotype from *Ramalina* species, Darwin Research Station sample 153, deposited in the collection of the University of California, Davis. Paratypes were from the following samples: Santa Cruz Island, old trail to Bella Vista, 81 and 83; Horneman Farm to grassland, 130, and 153; Santa María Island, 90; Pinzón Island, 97. Paratypes deposited at Davis and the California Academy of Sciences, Department of Invertebrate Zoology. The lengths of 14 specimens were from 120μ to 185μ with the majority being between 165μ and 170μ .

This species is related to *E. tessellatus*, and would key to that species in Ramazzotti (1962). However, the divisions of the scapular and terminal plates are different, and the spine A of *E. tessellatus* is very much longer.

The species is named for Dr. Carl B. Koford who collected the specimens from Santa María Island.

***Echiniscus quadrispinosus* Richters, 1902.**

(Figure 7.)

The longest of our 10 specimens is 190μ , but lengths of 280μ are recorded in literature. Eyes are absent. Smooth lateral spines are present at all positions. Dorsally C^d is usually present and smaller than D^d . The plates have punctures of irregular size and shape in addition to a fine, regular pattern between the punctures (best observed with a phase contrast microscope and at high magnification).

This series has been placed as *E. quadrispinosus* by Ramazzotti although the appendages are exceptionally short, and it keys to that species with difficulty. Dr. Ramazzotti expresses the opinion that it is a variable species in that respect, but that the double punctation of the cuticle identifies the species as *E. quadrispinosus*.

The species is known previously from Europe, Canary Island, Africa, North America, and South America. The Galápagos specimens were recovered on Santa Cruz Island from the following samples: old Bella Vista Trail, 81; Horneman Farm to grassland, 130, 141, and 154.

***Echiniscus duboisi* Richters, 1902.**

(Figure 8.)

The longest specimen measured 220μ , which approaches the reported maximum of 250μ . Lateral spines are present at all positions, and dorsal spines at C^d and D^d . The spines are usually somewhat serrate. The dorsal plates are punctate, similar to those of the preceding species, but the secondary pattern is absent. The specimens examined have shorter, less serrate spines than previously reported for the species.

Echiniscus duboisi is known from Australia, Java, Krakatau, South America, and South Africa. The Galápagos collections were as follows: Santa Cruz Island, Darwin Research Station, below barranco, 153; old trail to Bella Vista, 81; Horneman Farm to grassland, 130, and 150.

Genus *Pseudechiniscus* Thulin, 1911

Pseudechiniscus juanitae Barros, 1939.

(Figure 4.)

Pseudechiniscus juanitae is characterized by having the head and head appendages normal in shape and size, and by the absence of lateral appendages. The pseudosegmental plate is reported to be bilobed. However, in the series examined, this plate showed variation from a simple margin, to a narrow transverse flap, to 2 small triangular teeth, to 2 large rounded or acute processes. The latter would key in Ramazzotti (1962) to *P. ramazzottii* or to *P. scortecii* but would not fit their descriptions. The granulation of the plates is constant for specimens regardless of the development of the pseudosegmental plate, and these granules are large enough to preclude placing these specimens with *P. suillus* which has a simple plate margin.

Specimens were collected from Fernandina Island, sample 95, and from Santa Cruz Island, Horneman Farm to grassland numbers 130, 134, 150, and 141.

Suborder EUTARDIGRADA Marcus, 1927

Family MACROBIOTIDAE Thulin, 1928

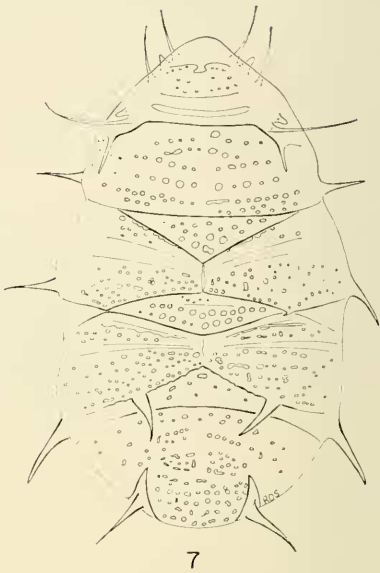
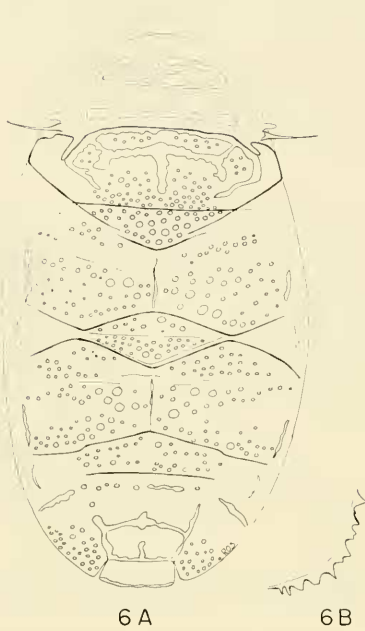
Genus *Macrobiotus* Schultze, 1834

Macrobiotus hufelandii Schultze, 1834.

(Figure 9.)

This species may be 300 μ to 400 μ long. The cuticle is smooth and frequently yellowish in color. The buccal tube is somewhat variable in width, but it is wider than that of *M. hibiscus* found on the mainland of Ecuador. The macroplacoids are rod-shaped, with the first slightly interrupted medially and longer than the second. A microplacoid is present. Processes of the egg are short, bulbous, and terminate with a tangential disc, similar to, but larger and fewer than the processes of *M. hibiscus*.

This cosmopolitan species is the most common member of the genus recovered on the Galápagos Islands. It was taken from the following samples: Wolf Island, 68, 70, and 71; Fernandina Island, 95, and 105; Pinzón Island, 96, 97, 146, and 151; Santa Cruz Island, Darwin Research Station below barranco, 38, 47, 138, 147, 153, and 166; at seismic station, 159, and 163; old trail to Bella Vista, 80, 81, 82, 83, 85, 107, 149, and 165; Horneman Farm to grassland, 125, 126, 127, 130, 134, and 135; Jensen Island, 92; Santa María, 90.



Macrobotus hibiscus Barros, 1942.

(Figure 10.)

Larger specimens of this species measure about 300μ . The body is white, and the cuticle smooth. Two macroplacoids and a microplacoid are present, with the first macroplacoid longer than the second. Both macroplacoids are shorter and wider than those of *M. hufelandii*. The egg is similar to that of *M. hufelandii* but the processes are smaller and more numerous.

This species was previously found only in Brazil. This series was recovered from a mixture of moss and lichen on trees in Guayaquil.

Macrobotus harmsworthi coronatus Barros, 1942.

(Figure 11.)

Larger individuals of this species may be over 300μ long. The body is white and the cuticle smooth. There are three rod-shaped macroplacoids, the first and third of approximately equal lengths, and slightly longer than the middle placoid. A microplacoid is present. The egg processes are elongate, conical, and have a distinct pattern. This pattern appears as a "crown of dots" when the bases of the process are in focus. The size and number of processes vary somewhat.

The distribution of *M. harmsworthi* is cosmopolitan, but this subspecies has been known previously only from Brazil and California. Specimens were recovered from Pinzón Island, 96, 97, and 146, and from the following Santa Cruz Island samples: Darwin Research Station, below the barranco, 153; the old Bella Vista trail, 80, 82, 83, 85, and 107; Horneman Farm to grassland, 123, 125, 126, 127, 130, 134, 135, 141, 150, and 154.

Macrobotus richtersi Murray, 1911.

(Figure 12.)

This is a rather large species. Specimens frequently are more than 500μ long. The body is white, and the cuticle smooth. The three macroplacoids are narrow rods of equivalent lengths, and the microplacoid is small. The buccal tube is very wide with the stylet supports positioned about as far from the base of the buccal tube as the tube is wide. The egg processes are hemispherical.

Macrobotus richtersi has been found in Europe, Africa, North America, and South America. Specimens were collected on Cocos Island, and in the Galápagos on two islands: Pinzón Island, 146; Santa Cruz Island, Horneman Farm to grassland, 123, 126, 130, and 135.

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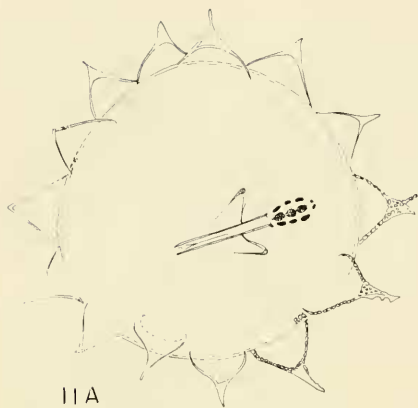
FIGURE 6. *Echiniscus kofordi*, new species. 6A, dorsum; 6B, collar leg IV; 6C, photomicrograph of cuticle.

FIGURE 7. *Echiniscus quadrispinosus* Richters. Dorsum.

FIGURE 8. *Echiniscus duboisi* Richters. Spines.

FIGURE 9. *Macrobotus hufelandii* Schultze. Processes of egg.

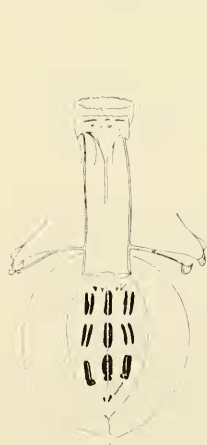
FIGURE 10. *Macrobotus hibiscus* Barros. 10A mouthparts, 10B egg.



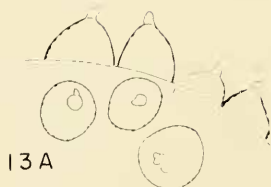
11A



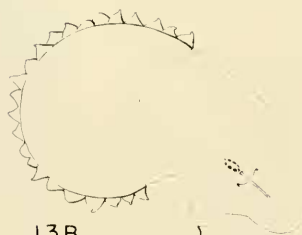
11B



12



13A



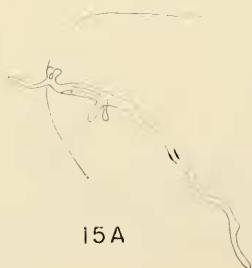
13B



13C



14



15A



15B

Macrobotus montanus Murray, 1910.

(Figure 13.)

Recorded specimens of *M. montanus* have a maximum length of 500 μ . They are white, and the cuticle smooth. The three macroplacoids are of subequal size and are globular. A small microplacoid is also present. The buccal tube is very narrow with the stylet supports attached near its middle.

Macrobotus montanus has been infrequently collected in Europe and Africa. Two specimens were recovered from Santa Cruz Island sample 80.

Genus Itaquascon Barros, 1939**Itaquascon umbellinae** Barros, 1939.

(Figure 15.)

The length of a single example is 350 μ . The cuticle is smooth and the color, which was not noted prior to mounting, is supposedly off-white or brownish. Eye spots are absent. The pharyngeal tube is thin and not annulate as in the only other species, *I. bartosi*. Placoids are absent.

A provisional identification is made in this case because the only available specimen, mounted in Fauré's, is insufficiently cleared. However, the species is known from both North and South America, and is probably correctly identified on the basis of the pharyngeal tube.

The specimen is from Santa Cruz Island, Horneman Farm to grassland, 154.

Family MILNESIIDAE Ramazzotti, 1962

Genus **Milnesium** Doyère, 1840**Milnesium tardigradum** Doyère, 1840.

(Figure 14.)

This species may exceed a length of 500 μ . The body color is variable, from red-brown, to white, or transparent, the cuticle is smooth. Distinct segmentation of the body is usually apparent. The buccal tube is short and thick, and the pharynx is without placoids. The species is easily recognized by the claws of which the proximal member is short and divided, and the distal member is long, thin, and entire.

Milnesium tardigradum is cosmopolitan, and was found on Cocos Island and in most of the Galápagos Island collections as listed below: Wolf Island,

←FIGURE 11. *Macrobotus harmsworthi coronatus* Barros. 11A, egg; 11B, mouthparts.FIGURE 12. *Macrobotus richtersi* Murray. Mouthparts.FIGURE 13. *Macrobotus montanus* Murray. 13A and 13B, egg; 13C, mouthparts.FIGURE 14. *Milnesium tardigradum* Doyère. Claws of leg IV.FIGURE 15. *Itaquascon umbellinae* Barros. 15A, mouthparts; 15B, claws leg IV.

70, and 71; Fernandina Island, 95; Pinzón Island, 96, 97, 146, and 151; Santa Cruz Island, Darwin Research Station below the barranco, 47, 147, 153, 158, 162, and 166; Darwin Research Station; at seismic stations, 159, 160, 161, and 163; old trail to Bella Vista, 80, 81, 82, 83, 85, 86, 107, 149, 156, 165; Horneman Farm to grassland, 126, 127, 116, 130, and 150; Santa María Island, 90; Cocos Island, Chatham Bay, 3.

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